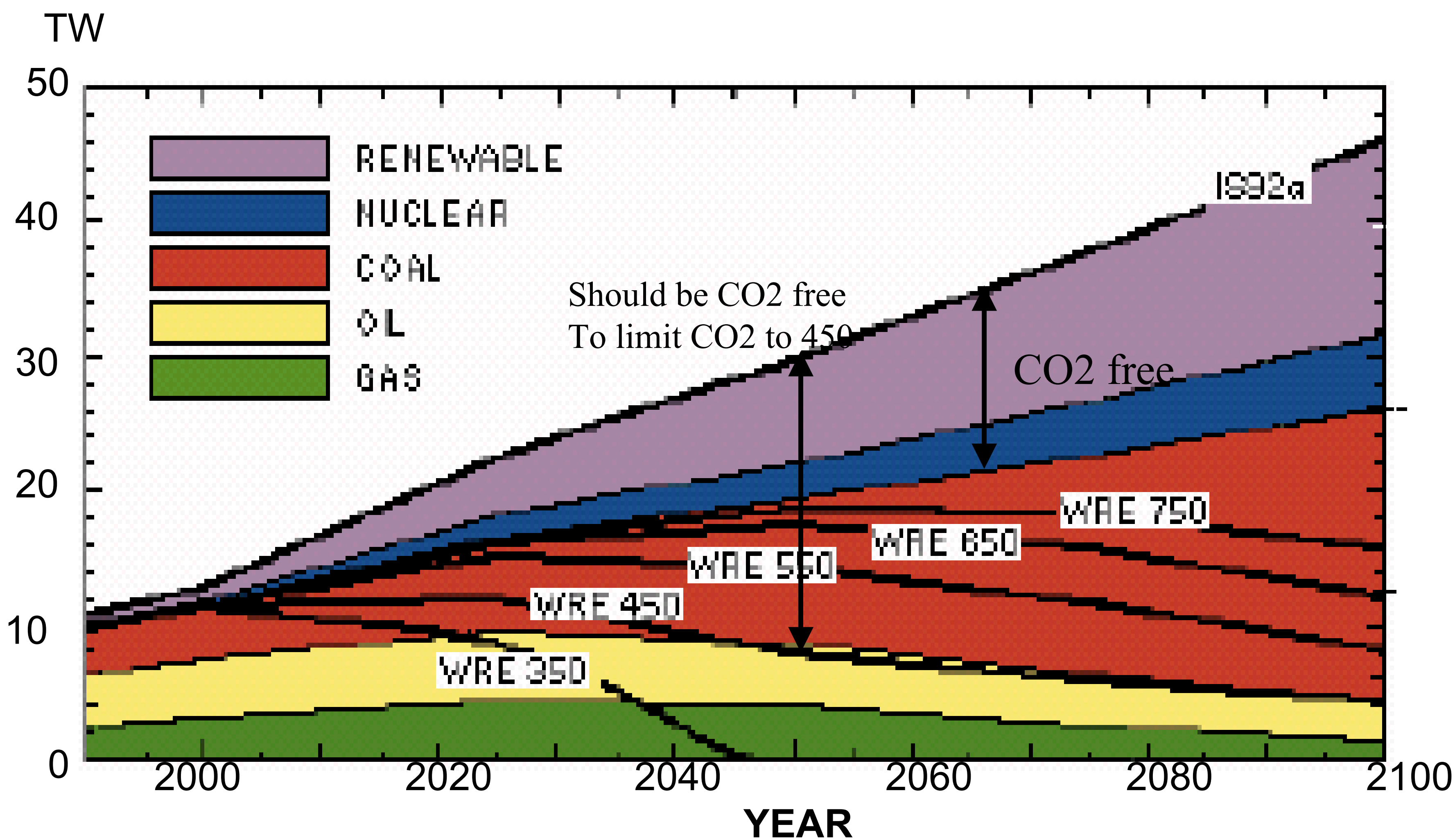
CHEMICALLY REACTING FLOW

1. Combustion
2. Fuel reforming and synthesis
3. Hydrogen production and storage
4. Fuel cells and batteries
5. Reactive material synthesis

IMPACT

1. Energy Independence (national security).
2. Health Risk (pollution and toxics).
3. Economic Competitiveness.

Through:
"Well-to-Wheel"
High efficiency, low emission and fast design
"using hydrogen is not the answer"



Source: M.I. Hoffert et. al., *Nature*, **1998**, *395*, 881,

THE MULTISCALE PROBLEM

Reacting Flow Problems include highly nonlinear, strongly coupled physics, chemistry and transport:

1. Acoustics, O(1 m).
2. Convection with multiphase, O(0.1 m).
3. Diffusion, O(0.1 mm).
4. Chemical reactions with soot (nano-C), O(0.001 mm).
5. Radiation.

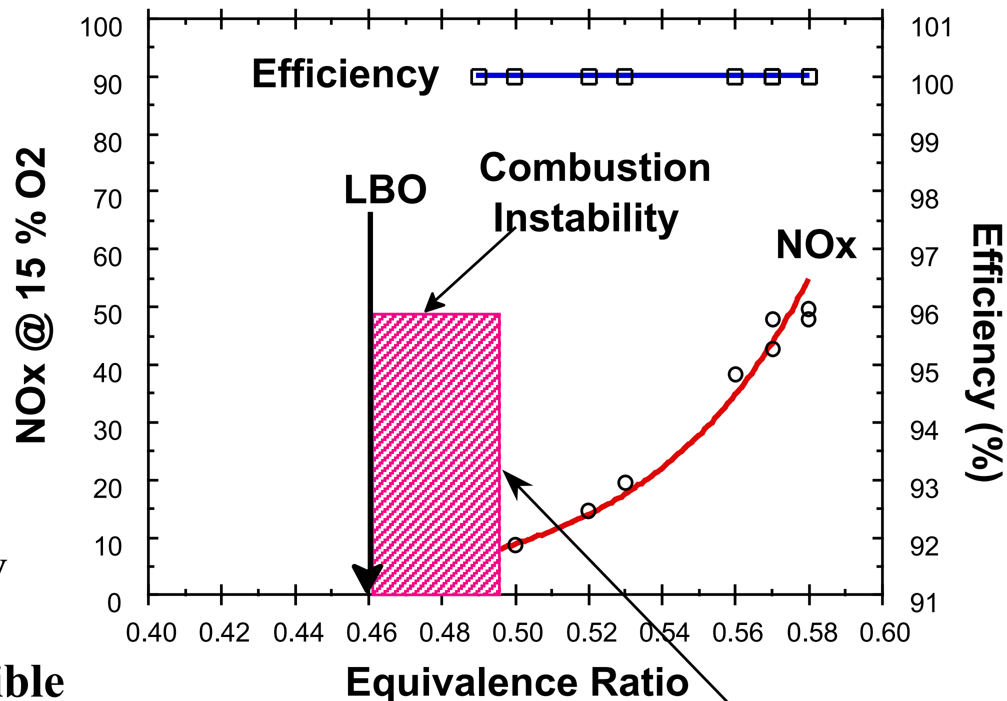
Length scales: 6 decades
Time scale: 8 decades

Bill Proscia, UTRC

Combustion Instabilities Limit Minimum Achievable NOx Emissions

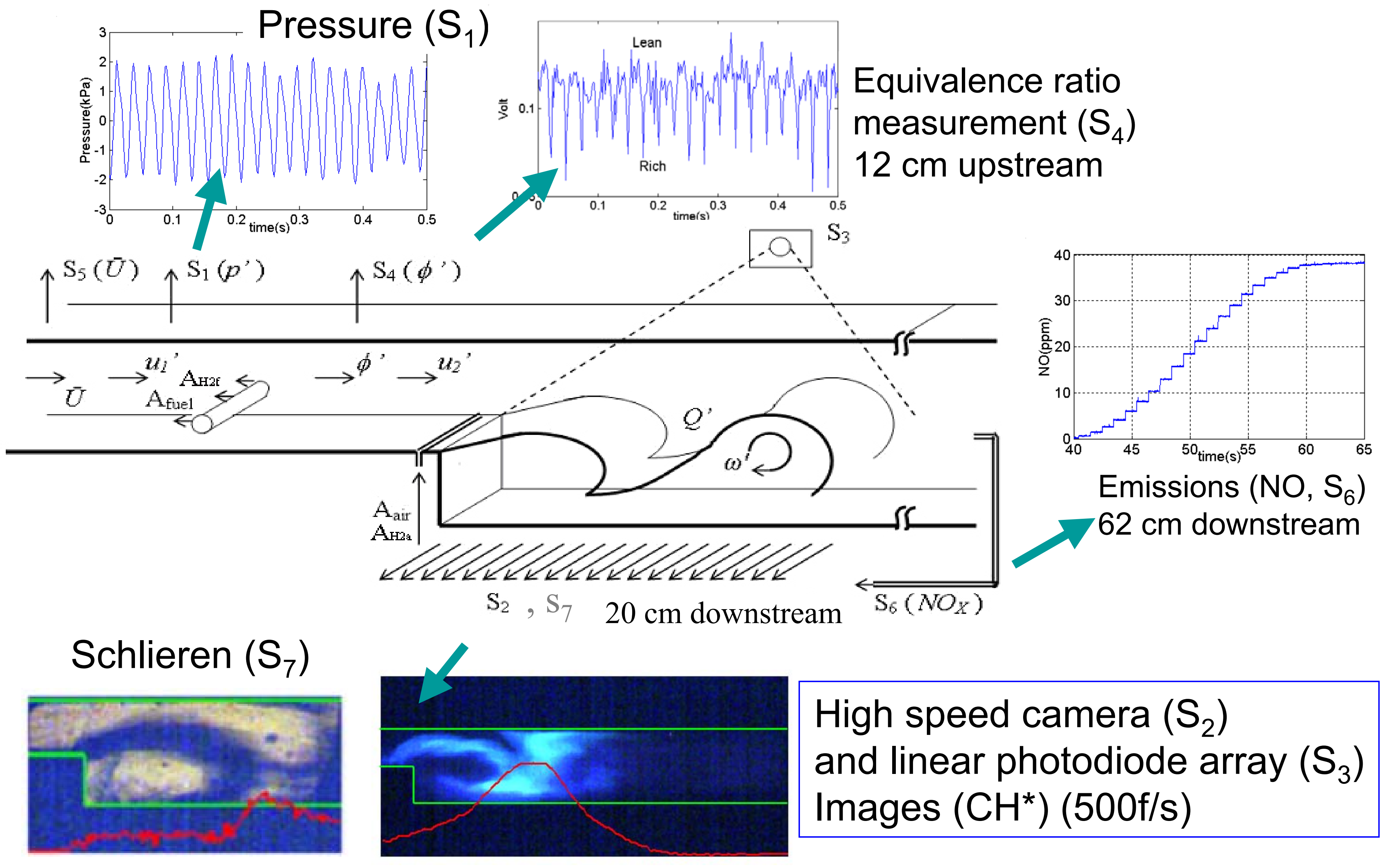
- **P&W DLN+ Goals:**
  - 15 ppm / 15 ppm NOx/CO
  - RMS pressure < 1.7 psi
  - FT8 and FT4000SC cycles
- **Wide range of operating conditions**
  - 50 - 100% power
  - -40 to 120 F ambient temp.
- **Air bypass design**
  - enables emissions goals
  - variable convective delay
- **Instabilities inevitable**
  - op. condns. --> combustion delay
  - air bypass --> convective delay
- **Passive design solution *may* be possible**
- **AIC can enable product**

Product Need

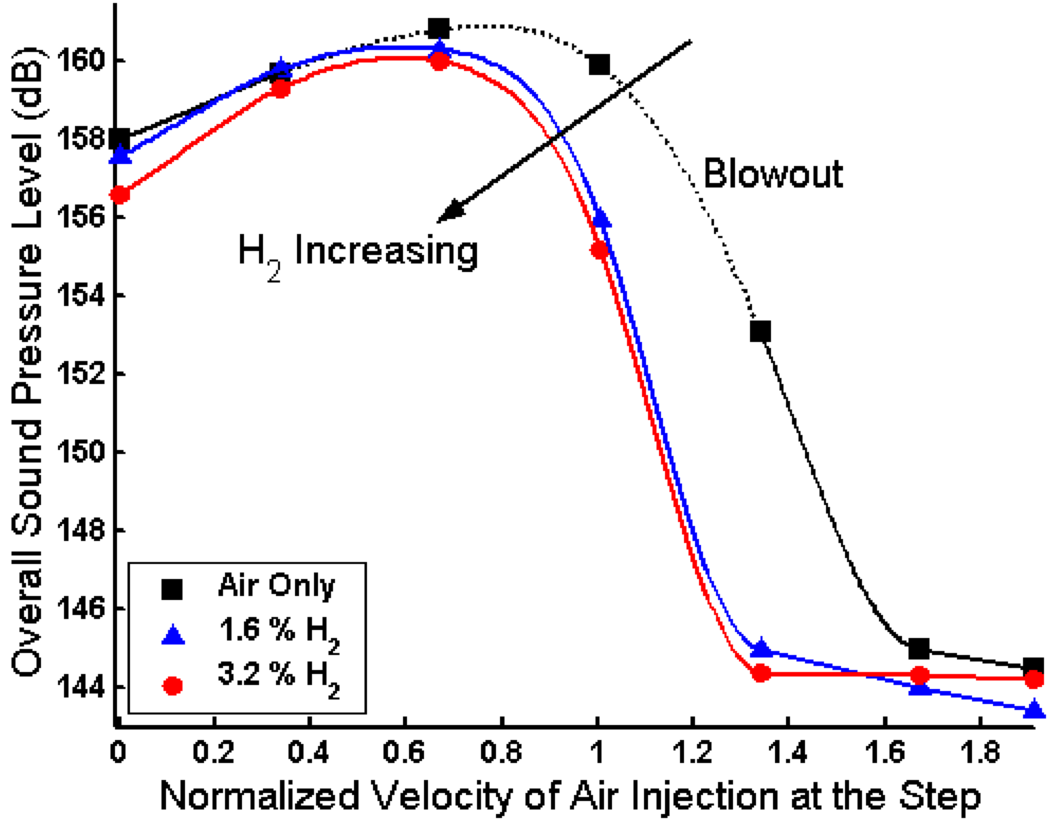


"Stability boundary" defined as maximum allowable pressure fluctuation level

Low emission burning leads to instability



Dependence of OASPL on Air Jet Velocity and H2

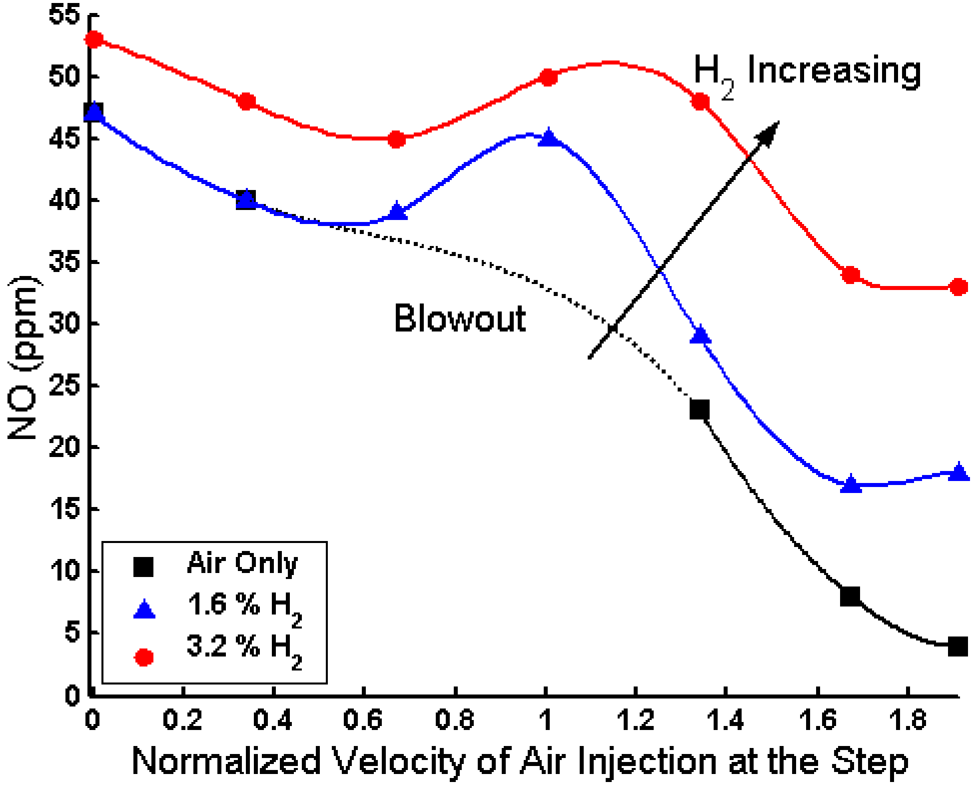


•Baseline $\phi = 0.57$

$0.57 < \phi < 0.47$

- A relatively large transverse jet velocity was necessary to reduce the pressure fluctuations by 14 dB, penetration is important.
- H2 addition is to support a more stable flame, lowering pressure oscillation and preventing blowout.

Dependence of NOx on Air Jet Velocity and H2



- Introduction of an air jet reduces NO levels by an order of magnitude
- Hydrogen addition under the same conditions boosts NO levels

QuickTime™ and a
MPEG-4 Video decompressor
are needed to see this picture.